UNIVERSITAT POLITÈCNICA DE CATALUNYA
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BEKASI-EAST JAKARTA AIRPORT

AIR SIDE

Report

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1 Airport location and characterization

1.1 Location

The main influence on the airport location is the presence of other airports in the area. Since Jakarta has already one airport, the 18th worldwide, the location has to be selected carefully. Other factors that influenced the airports final location were the ease to provide the airport with good connections to the city and a wide area available in order to increase the airports infrastructure if needed in the future. After considering all those factors, the location decided can be defined by the following coordinates:

- Latitude: 6°08'21"

- Longitude: 107°06'40"

- Altitude: 30meters approximately.

Since the area chosen is extremely marshy, the excavations to deeper levels are going to be avoided as much as possible due to its difficulties and cost. However, that type of terrain gives us some advantage due to its flatness.

1.2 Meteorology

1.2.1 Temperature

The reference temperature of airports is important to be calculated as soon as possible since it has an effect on the performance of the airplanes during the phases of landing and takeoff.

In order to calculate this temperature, the definition given by the OACI will be used. OACI states that: "The aerodrome reference temperature shall be the monthly mean of the daily maximum temperatures for the hottest month of the year (the hottest month being that which has the highest monthly mean temperature). This temperature shall be averaged over a period of years".

Taking into account the hypothesis that the temperatures obtained on Soekarno-Hatta Airport can also be used in order to calculate our reference temperature due to the fact that both airports are only separated by a distance of 60km, a comparison study has been made.

The final reference temperature obtained is $T_{ref} = 32,38°C$.

The temperature values and study is further detailed in the attachments.

1.2.2 Wind

In order to calculate the influence of the winds the first thing done is the graph of the winds intensity and their direction. This graph is commonly called wind rose graph. The graph obtained making use of Microsoft Excel software is:

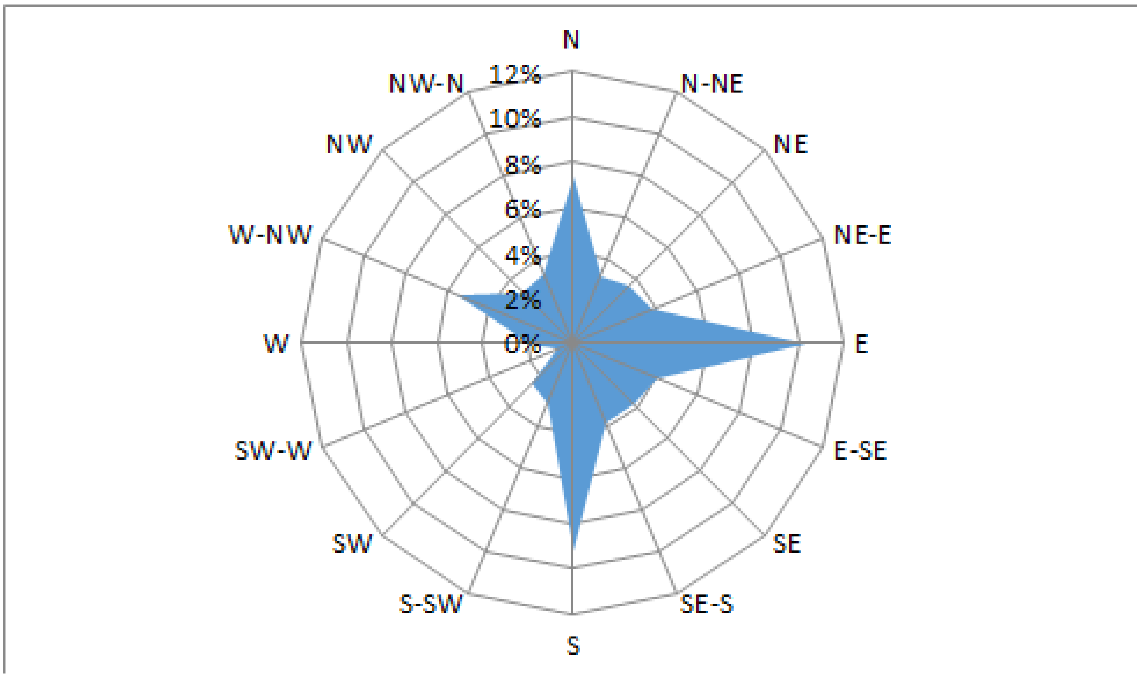

Figure 1.2.1: Wind Rose Graph

Once this step is done, the next thing to do is to calculate the coefficient of use by a diagram of frequencies. Following the recommendations given by the ICAO on the attachment 14, the maximum value that the transversal component can achieve is 37km/h or 20knots for a runway of >1500m.

The diagram of frequencies basically creates a rectangular area that depends on the runway axis, the width of the runway and the maximum transversal component.

After calculating the coefficient of use by all the directions, the graph obtained is the following:

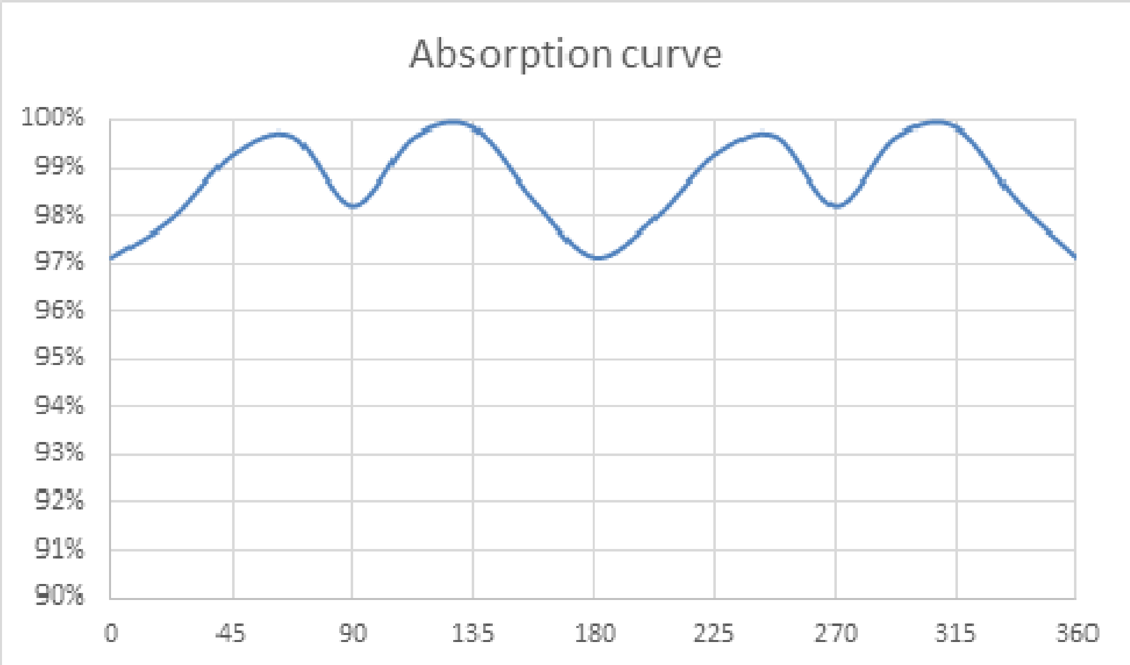

Figure 1.2.2: Coefficient of use depending on the orientation

As it can be see, the coefficient is higher than 95% in any direction. According to that, the final orientation chosen is SE-NW.

2 | Runway design

2.1 Introduction

The runway is a key piece of the airport and the air side design due to the fact that defines the maximum dimensions of the operative air planes. Its function is to successfully guarantee the landing and takeoff operation.

In order to successfully define the runway, the instructions and requirements given in the Annex 14 given by the ICAO have been followed.

2.2 Runway Length

The reference field length is defined as the minimum distance needed in order to perform a takeoff operation with the maximum homologated takeoff weight using sea level conditions, without wind and considering 0° slope.

In order to calculate the runway length, the first step is to choose the most restrictive air plane that is going to operate on that runway. Afterwards, that length has to be corrected by the runway slope, the altitude of the airport and the mean temperature.

Due to the fact that the airport has two runways, from now on, the runway used for international flights will be referred as runway 1 and the one used for domestic flights will be named runway 2.

2.2.1 Runway 1

The biggest airplanes that will operate on this runway are the Boeing 777-300ER and the Airbus A330-300.

2.2.1.1 Reference Field Length

Starting with the B777-300ER, using the ACAP (Aircraft Characteristic for Airport Planning), the values of the MTOW (Maximum TakeOff Weight) and MLW (Maximum Landing Weight) can be obtained.

2.1.1 General Characteristics: Model 777-200LR. -300ER, 777F

CHARACTERISTICS	UNITS	777-200LR	777-300ER	777-F
MAX DESIGN TAXI WEIGHT	POUNDS	768,000	777,000	768,800
	KILOGRAMS	348,358	352,442	348,722
MAX DESIGN TAKEOFF WEIGHT	POUNDS	766,000	775,000	766,800
	KILOGRAMS	347,452	351,535	347,815
MAX DESIGN LANDING WEIGHT	POUNDS	492,000	554,000	575,000
	KILOGRAMS	223,168	251,290	260,816
MAX DESIGN ZERO FUEL WEIGHT	POUNDS	461,000	524,000	547,000
	KILOGRAMS	209,106	237,683	248,115
OPERATING EMPTY WEIGHT (1)	POUNDS	320,000	370,000	318,300
	KILOGRAMS	145,150	167,829	144,379
MAX STRUCTURAL PAYLOAD	POUNDS	141,000	154,000	228,700
	KILOGRAMS	63,957	69,853	103,737
TYPICAL SEATING CAPACITY	TWO CLASS	279 (4)	339 (6)	N/A
	THREE CLASS	301 (5)	370 (7)	N/A
MAX CARGO --LOWER DECK	CUBIC FEET	5,656 (2)	7,552 (2)	22,371 (3)
	CUBIC METERS	160.2 (2)	213.8 (2)	633.5 (3)
USABLE FUEL	U.S. GALLONS	47,890	47,890	47,890
	LITERS	181,283	181,283	181,283
	POUNDS	320,863	320,863	320,863
	KILOGRAMS	145,538	145,538	145,538

Figure 2.2.1: Maximum weights of the B777 depending on its configuration.

The next step is to calculate using the following graph the takeoff distance required with standard day + 15ºC = 30ºC and sea level conditions.

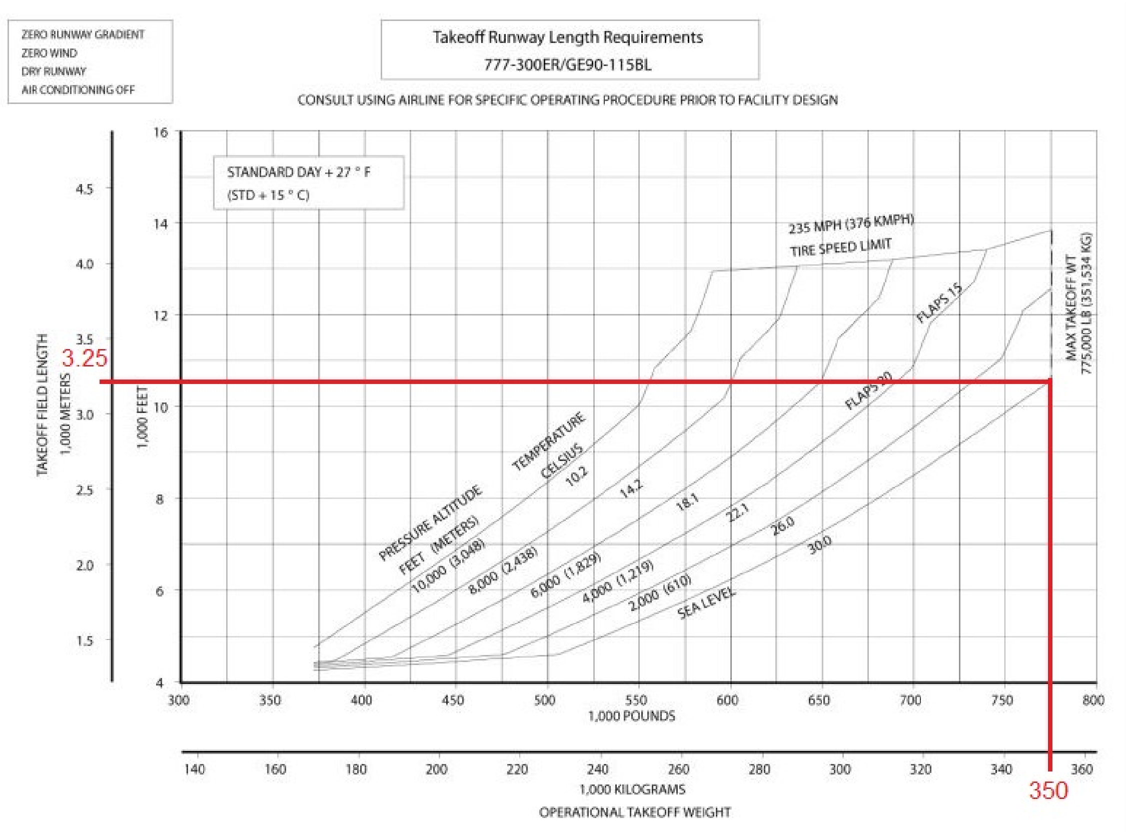

Figure 2.2.2: Relation between the MTOW and the takeoff distance.

As it is seen on the graph above, the length taken as reference (LCR) is 3.250m in a standard day+15ºC and sea level conditions.

The same procedure has to be done with the Airbus A330-300 in order to compare which one is the most restrictive one. Using the ACAP (Aircraft Characteristic for Airport Planning), the MTOW and MLW obtained are the following:

Aircraft Characteristics				
	WV000	WV001	WV002	WV003
Maximum Taxi Weight (MTW) Maximum Ramp Weight (MRW)	212 900 kg (469 364 lb)	184 900 kg (407 635 lb)	212 900 kg (469 364 lb)	215 900 kg (475 978 lb)
Maximum Take-Off Weight (MTOW)	212 000 kg (467 380 lb)	184 000 kg (405 650 lb)	212 000 kg (467 380 lb)	215 000 kg (473 994 lb)
Maximum Landing Weight (MLW)	174 000 kg (383 604 lb)	174 000 kg (383 604 lb)	177 000 kg (390 218 lb)	177 000 kg (390 218 lb)
Maximum Zero Fuel Weight (MZFW)	164 000 kg (361 558 lb)	164 000 kg (361 558 lb)	167 000 kg (368 172 lb)	167 000 kg (368 172 lb)

Figure 2.2.3: Maximum A330's weights.

Since the difference on the MTOW and MLW between both planes is greater than a 50%, the Boeing's Reference Field Length is chosen as the critical without calculating the Reference Field Length of the A330-300.

Once the most restrictive plane is chosen, the next step is to correct the length following ICAO's instructions. The equation used to correct the altitude difference is:

$$L_t = RFL * (1 + 0,07 * \frac{\Delta h}{300})$$

Solving the equation for a RFL of 3.250m and an increase on the altitude of 100m, the result obtained is 3326m. Since the temperature has already been corrected on the graph and the runway slope is going to be less than 0,5% and thus, it can be neglected, the final length will be 3.500m rounding up.

2.2.1.2 Reference code

Using the dimensions of the B777-300ER and the tables given by the ICAO, the number and letter that define the runway can be obtained.

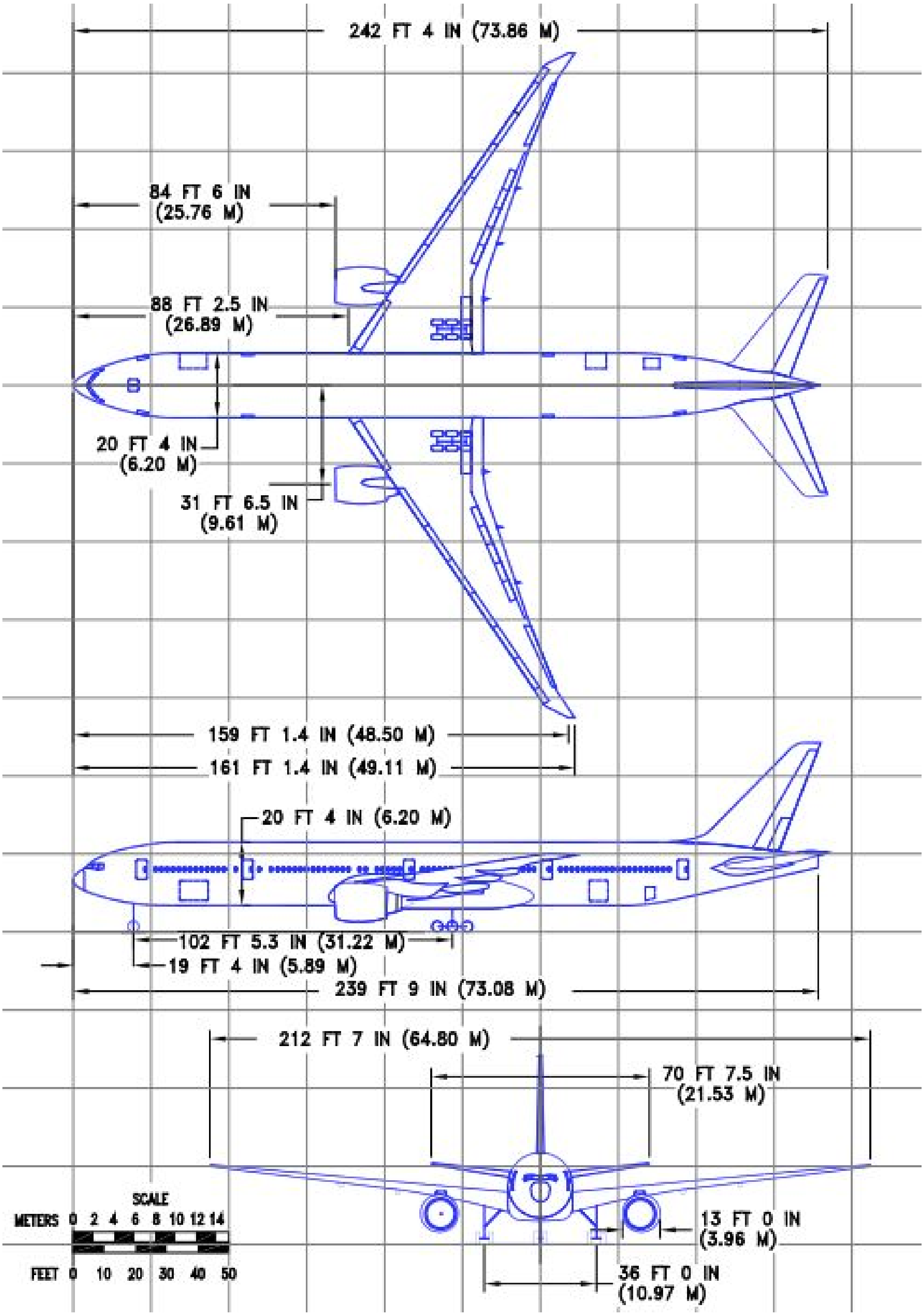

Figure 2.2.4: Boeing 777-300ER dimensions.

Code element 1		Code element 2		
Code number (1)	Aeroplane reference field length (2)	Code letter (3)	Wingspan (4)	Outer main gear wheel span[a] (5)
1	Less than 800 m	A	Up to but not including 15 m	Up to but not including 4.5 m
2	800 m up to but not including 1 200 m	B	15 m up to but not including 24 m	4.5 m up to but not including 6 m
3	1 200 m up to but not including 1 800 m	C	24 m up to but not including 36 m	6 m up to but not including 9 m
4	1 800 m and over	D	36 m up to but not including 52 m	9 m up to but not including 14 m
		E	52 m up to but not including 65 m	9 m up to but not including 14 m
		F	65 m up to but not including 80 m	14 m up to but not including 16 m

a. Distance between the outside edges of the main gear wheels.

Figure 2.2.5: Reference code given by the ICAO.

Due to the RFL being higher than 1800m , the reference number of the runway is number 4 according to ICAO and due to the dimensions of the air plane B777-300ER, which has a span of 64,8m<65m and a distance between the landing gear of 10,97m<14m, the letter that defines the airport is E.

2.2.1.3 Runway width and shoulders

The runway width is obtained using the ICAO recommendations stated on the Annex 14 and the key reference of the runway.

Code number	Code letter A	B	C	D	E	F
1[a]	18 m	18 m	23 m	–	–	–
2[a]	23 m	23 m	30 m	–	–	–
3	30 m	30 m	30 m	45 m	–	–
4	–	–	45 m	45 m	45 m	60 m

Figure 2.2.6: Runway width according to ICAO.

As it can be seen, and remembering that our key reference is 4E, the minimum runway width needed is 45m. This value has to be further increased with the use of runway shoulders up to a minimum of 60m.

2.2.1.4 Declared distances

The calculations done in order to obtain the final value can be seen on the airside's attachments section 1.

To sum up, the final values obtained are:

Landing Distance Available	3.500m
TakeOff Distance Available (TODA)	4.460m
TakeOff Run Available (TORA)	3.760m
Accelerate-Stop Distance Available (ASDA)	4.360m

Table 2.2.1: Declared distances of Runway 1

An schematic figure will be attached in order to ease the understanding of the declared distances:

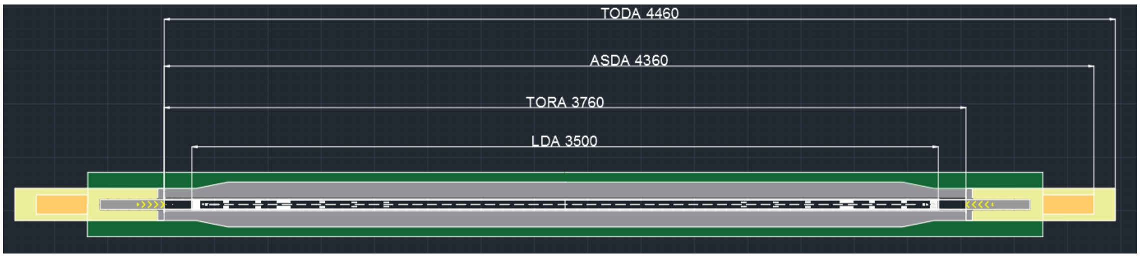

Figure 2.2.7: Declared distances on CAD.

2.2.1.5 Runway strips

The strip is a delimited area of terrain centred in the runway that has the function of reducing the air plane's risk of getting out of the runway.

According to ICAO's rule number 3.4.2 and 3.4.3, all the runways with a reference number of 4 must contain a strip in each side of the runway's axis. The minimum distance has to be 150m and has to be extended a minimum of 60m after the threshold. Following the rule 3.4.8, the first 150m from the threshold have to be separated at least 75m form the runway's axis. Past those 150m, the strip has to grow linearly until reaching the strip levelled zone.

2.2.1.6 Runway End Saefty Areas (RESA)

According to ICAO's rule number 3.5.1, the airport with a reference number of 4 has to have a runway end safety area that should extend over a distance of at least 90m. Furthermore, as it is said in the point 3.5.5, the width of a runway end safety area shall be at least twice that of the associated runway.

2.2.1.7 Clearway (CWY)

Following the recommendation number 3.6.2 and 3.6.3, the Clearway has its beginning at the end of the maximum takeoff distance available and its maximum length should be half that distance. Furthermore, the clearway should have a with of at least 75m on each side of the runway's axis.

2.2.1.8 Stopway (SWY)

When it comes to the stopway, following the ICAO's rules, the stopway shall have the same width as the runway with which it is associated.

2.2.2 Runway 2

In this case, the planes that are going to be evaluated are the Boeing 737-800 and the Airbus 320-200.

2.2.2.1 Reference Field Length

Searching the values of MTOW and MLW stated on the ACAP of the Boeing 737, the values obtained are 79.000kg for the MTOW and 66.300kg for the MLW.

CHARACTERISTICS	UNITS	MODEL 737-800, -800 WITH WINGLETS		
MAX DESIGN TAXI WEIGHT	POUNDS	156,000	173,000	174,900
	KILOGRAMS	70,760	78,471	79,333
MAX DESIGN TAKEOFF WEIGHT	POUNDS	155,500	172,500	174,200
	KILOGRAMS	70,534	78,245	79,016
MAX DESIGN LANDING WEIGHT	POUNDS	144,000	144,000	146,300
	KILOGRAMS	65,317	65,317	66,361
MAX DESIGN ZERO FUEL WEIGHT	POUNDS	136,000	136,000	138,300
	KILOGRAMS	61,689	61,689	62,732
OPERATING EMPTY WEIGHT (1)	POUNDS	91,300	91,300	91,300
	KILOGRAMS	41,413	41,413	41,413
MAX STRUCTURAL PAYLOAD	POUNDS	44,700	44,700	47,000
	KILOGRAMS	20,276	20,276	21,319
SEATING CAPACITY (1)	TWO-CLASS	160	160	160
	ALL-ECONOMY	184	184	184

Figure 2.2.8: Maximum weights of the B737 depending on its configuration.

As for the B777, the next step is to calculate using the following graph the takeoff distance required with standard day + 15ºC = 30ºC and sea level conditions using the MTOW.

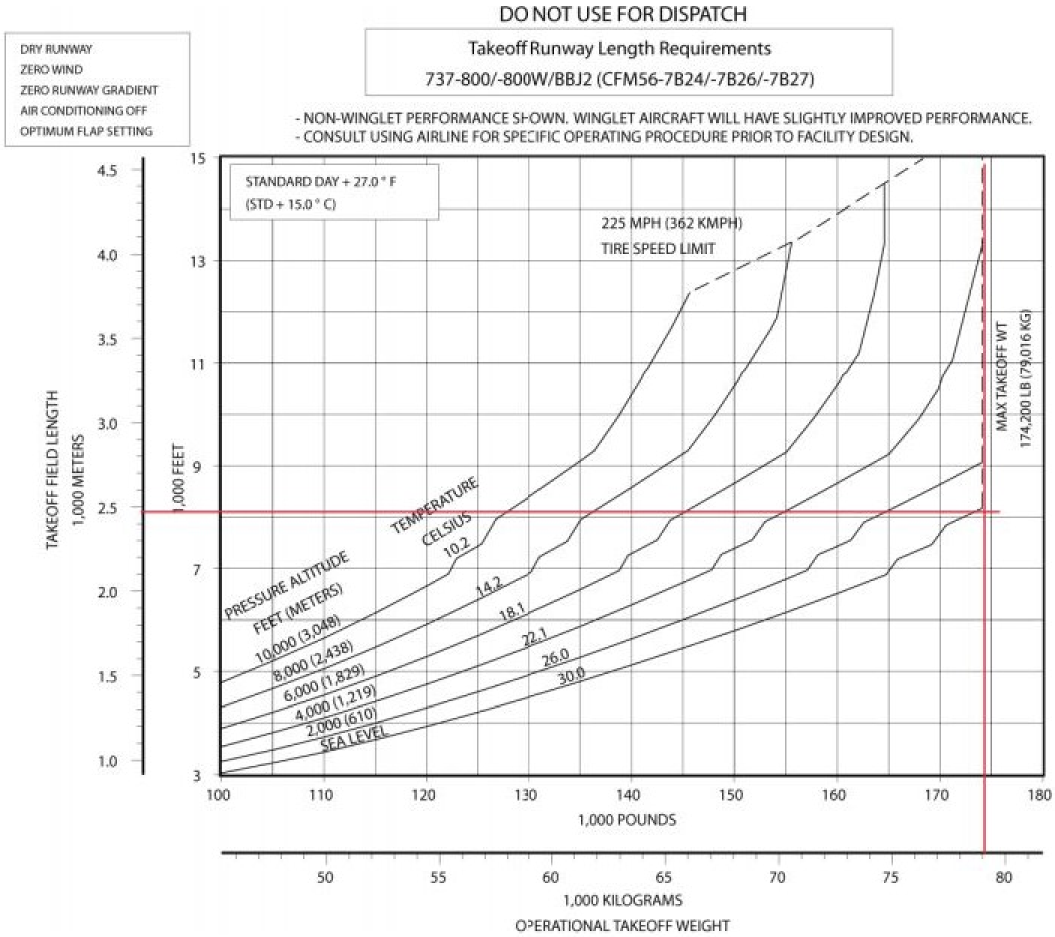

Figure 2.2.9: Relation between the MTOW and the takeoff distance.

The value of the RFL obtained is 2.450m approximately in standard day and sea level conditions.

The same procedure has to be done with the Airbus A320-200 in order to compare which one is the most restrictive one. Using the ACAP (Aircraft Characteristic for Airport Planning), the MTOW and MLW obtained are the following:

Aircraft Characteristics					
	WV000	WV001	WV002	WV003	WV004
Maximum Ramp Weight (MRW) Maximum Taxi Weight (MTW)	73 900 kg (162 922 lb)	68 400 kg (150 796 lb)	70 400 kg (155 205 lb)	75 900 kg (167 331 lb)	71 900 kg (158 512 lb)
Maximum Take-Off Weight (MTOW)	73 500 kg (162 040 lb)	68 000 kg (149 914 lb)	70 000 kg (154 324 lb)	75 500 kg (166 449 lb)	71 500 kg (157 630 lb)
Maximum Landing Weight (MLW)	64 500 kg (142 198 lb)	64 500 kg (142 198 lb)	64 500 kg (142 198 lb)	64 500 kg (142 198 lb)	64 500 kg (142 198 lb)
Maximum Zero Fuel Weight (MZFW)	60 500 kg (133 380 lb)	60 500 kg (133 380 lb)	60 500 kg (133 380 lb)	60 500 kg (133 380 lb)	60 500 kg (133 380 lb)

Figure 2.2.10: Maximum weights of the A320 depending on its configuration.

Due to the fact that the MTOW and the MLW of the B737 are higher than the A320 ones, the plane B737 is chosen as the critical for the design of the runway.

The next step is to correct the field length using the equation stated above, on the calculations for runway 1.

$$L_t = RFL * (1 + 0,07 * \frac{\Delta h}{300})$$

Solving the equation for a RFL of 2.450m and an increase on the altitude of 100m, the result obtained is 2500m. The same hypotheses used on the runway number 1 will be applied regarding the temperature and slope of the runway. Thus, the final length will be 2500m.

2.2.2.2 Reference code

Using the dimensions of the B737-800 and the tables given by the ICAO, the number and letter that define the runway can be obtained.

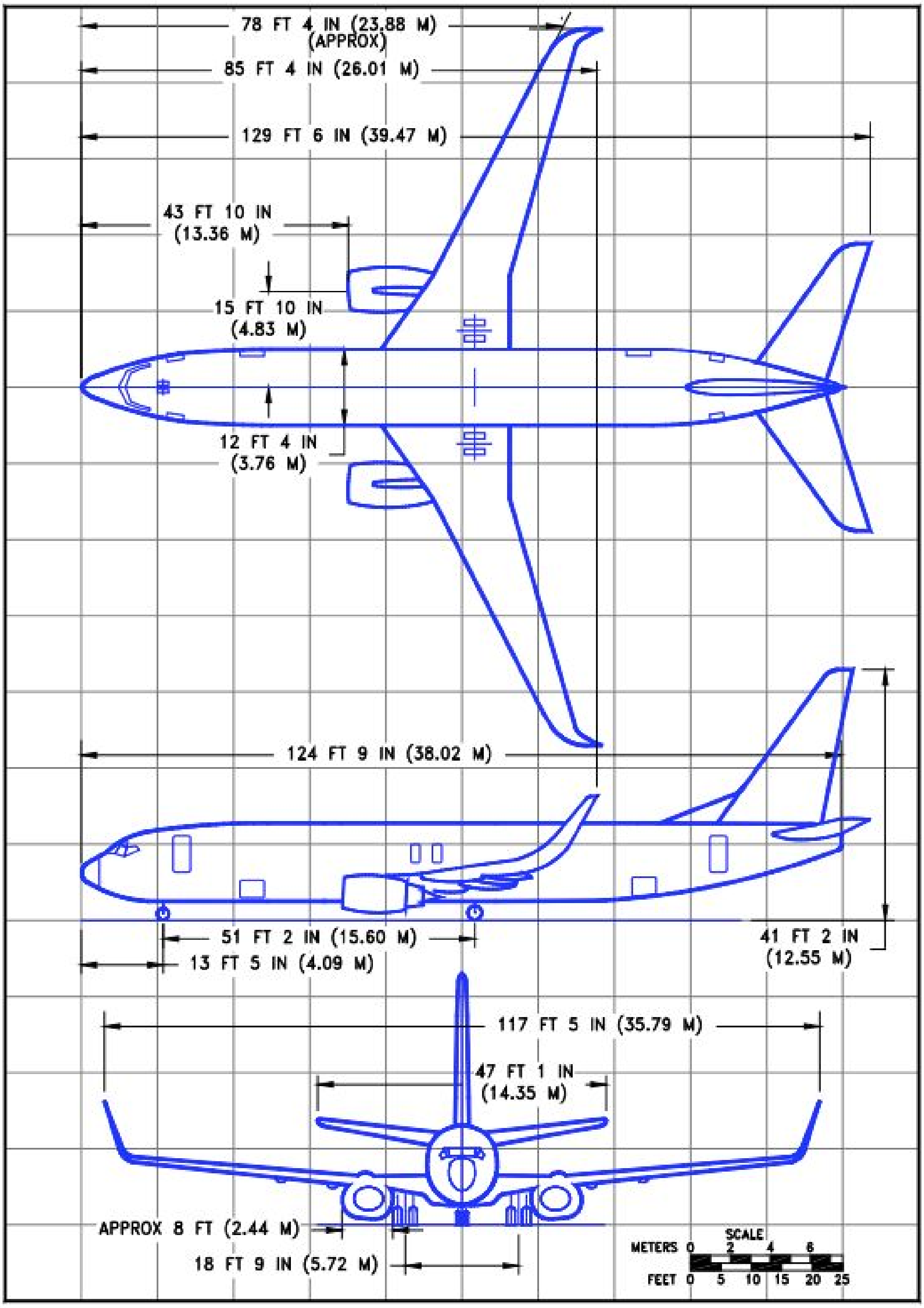

Figure 2.2.11: Boeing 737-800 dimensions.

Due to the RFL being higher than 1800m , the reference number of the runway is 4 according to ICAO and due to the dimensions of the air plane B737-800, which has a span of 35,8m<36m and a distance between the landing gear of 6m<9m, the letter that defines the airport is C.

2.2.2.3 Runway width and shoulders

The runway width is obtained using the ICAO recommendations stated on the Annex 14 and the key reference of the runway.

Code number	Code letter					
	A	B	C	D	E	F
1[a]	*18 m*	*18 m*	*23 m*	–	–	–
2[a]	*23 m*	*23 m*	*30 m*	–	–	–
3	*30 m*	*30 m*	*30 m*	*45 m*	–	–
4	–	–	*45 m*	*45 m*	*45 m*	*60 m*

Figure 2.2.12: Runway width according to OACI.

As it can be seen, and remembering that our key reference is 4C, the minimum runway width needed is 45m. This value has to be further increased with the use of runway shoulders up to a minimum of 60m.

2.2.2.4 Declared distances

As for the runway 1, the calculations done in order to obtain the final value can be seen on the airside's attachments section 1.

To sum up, the final values obtained are:

Landing Distance Available	2.500m
TakeOff Distance Available (TODA)	3.160m
TakeOff Run Available (TORA)	2.750m
Accelerate-Stop Distance Available (ASDA)	3.400m

Table 2.2.2: Declared distances of Runway 2

2.2.2.5 Runway strips

As for the runway 1, due to the fact that both runways share the same reference number and the legislation does not make any distinction using the reference letter, the dimensions of the strips of runway 2 are exactly the same as runway 1.

2.2.2.6 Runway End Saefty Areas (RESA)

According to ICAO's rule number 3.5.1, the airport with a reference number of 4 has to have a runway end safety area that should extend over a distance of at least 90m. Furthermore, as it is said in the point 3.5.5, the width of a runway end safety area shall be at least twice that of the associated runway.

2.2.2.7 Clearway (CWY)

Following the recommendations 3.6.2 and 3.6.3, the CWY have its origin at the end of the RESA and shall extend to a maximum of half the runway length.

3 Taxiway design

3.1 Introduction

3.2 Taxiway width

3.3 Taxiway turns

3.4 Taxiway overwidths (sobreanchos)

3.5 Taxiway shoulders

3.6 Taxiway strips

3.7 Rapid exit taxiways

3.7.1 Introduction

3.7.2 Number of rapid exit taxiways

3.7.3 Design of rapid exit taxiways

4 Holding positions

4.1 Introduction

4.2 Minimum distance between holding position and runway

4.3 Interference with critical and ILS sensible areas

4.4 Interference with CWY and physical obstacles

4.4.1 Separation between aircraft (guardas entre aeronaves)

4.5 Final design of holding positions

5 Apron design

5.1 Introduction

The apron is the area of an airport where the aircraft are parked, unloaded or loaded, refuelled and boarded. It also has to cover the taxiways and the trajectories that air planes have to take in order to get to the principal taxiways or the station zones.

Another function that the apron has to full-fill is the creation of a service way that will allow all the different services needed by the plane to get to it and the creation of some waiting positions for them that will not obstacle the manoeuvres of the plane. Last but not least, the connection between air-side and land-side is under the responsibility of the apron.

Before moving into a more detailed explanation of each part that makes the apron, a general view is going to be attached in order to obtain a general idea of what is the apron.

Code number	Code letter					
	A	B	C	D	E	F
1[a]	*18 m*	*18 m*	*23 m*	–	–	–
2[a]	*23 m*	*23 m*	*30 m*	–	–	–
3	*30 m*	*30 m*	*30 m*	*45 m*	–	–
4	–	–	*45 m*	*45 m*	*45 m*	*60 m*

Figure 5.1.1: Runway width according to OACI.

The sections of the apron that will be further explained are the apron taxiways, the aircraft stands, the apron trajectories, service ways and terminal connections.

5.2 Apron taxiways

Apron taxiways are designed in order to allow the aircraft to move from the principal taxiway to its specific apron. Due to the fact that our airport has two runways, the number of auxiliary taxiways is higher than a simpler airport. However, ICAO does not have a different criteria for these taxiways. Thus, the parameters and restrictions that apply on the auxiliary taxiways is the same than the principal ones.

Even though the airport is divided in two differenced parts, the domestic flights which have the B737 as most restrictive aircraft and the internationals flights with the B777 as critical air plane, the auxiliary taxiways are designed in order to allow the B777 to operate in the whole airport.

The line that limits the space where aircraft are allowed to taxi is an orange line surrounded by two white lines as it is stated on the ICAO's manual. Since the most restrictive reference letter is E, as it can be seen in the table attached below, the minimum distance between the taxiway's axis is 80m.

Code letter	Distance between taxiway centre line and runway centre line (metres) — Instrument runways, Code number 1	2	3	4	Non-instrument runways, Code number 1	2	3	4	Taxiway centre line to taxiway centre line (metres)	Taxiway, other than aircraft stand taxilane, centre line to object (metres)	Aircraft stand taxilane centre line to aircraft stand taxilane centre line (metres)	Aircraft stand taxilane centre line to object (metres)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
A	82.5	82.5	–	–	37.5	47.5	–	–	23	15.5	19.5	12
B	87	87	–	–	42	52	–	–	32	20	28.5	16.5
C	–	–	168	–	–	–	93	–	44	26	40.5	22.5
D	–	–	176	176	–	–	101	101	63	37	59.5	33.5
E	–	–	–	182.5	–	–	–	107.5	76	43.5	72.5	40
F	–	–	–	190	–	–	–	115	91	51	87.5	47.5

Note 1.— The separation distances shown in columns (2) to (9) represent ordinary combinations of runways and taxiways. The basis for development of these distances is given in the Aerodrome Design Manual *(Doc 9157), Part 2.*

Note 2.— The distances in columns (2) to (9) do not guarantee sufficient clearance behind a holding aeroplane to permit the passing of another aeroplane on a parallel taxiway. See the Aerodrome Design Manual *(Doc 9157), Part 2.*

Figure 5.2.1: Design distances for taxiways according to ICAO.

5.3 Aircraft stands

5.3.1 General dimensions of aircraft stands

In order to dimension the aircraft stands, the dimensions of the aircraft stated on their ACAP and the ICAO's recommendations have been followed. Starting with the recommendation, the following table shows the distance depending on the reference letter of the air plane.

Code letter	Clearance
A	*3 m*
B	*3 m*
C	*4.5 m*
D	*7.5 m*
E	*7.5 m*
F	*7.5 m*

Figure 5.3.1: Clearance distances depending on the reference letter.

In order to understand how the aircraft stands are shaped, the following image is attached:

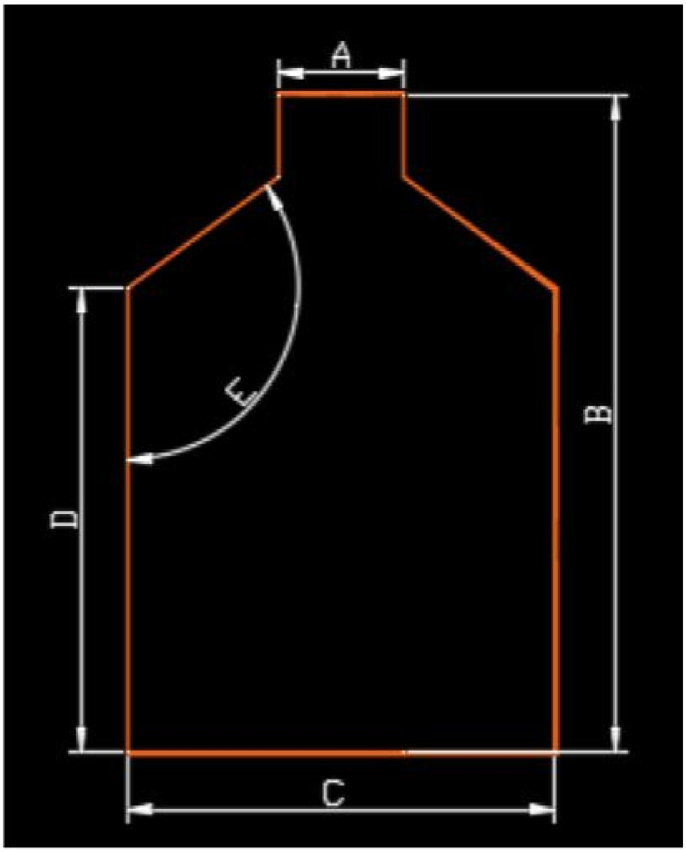

Figure 5.3.2: Clearance distances depending on the reference letter.

The next step is to explain how can each distance be obtained:

- A: this distance can be calculated by adding the maximum width of the air plane and the security margin stated on the table attached above.

- B: It can be dimensioned by adding two times the security margin stated by ICAO's recommendation and the aircraft length. The security margin is considered two times since the distance has to be respected in the front part and the rear part of the air plane.

- C: Once more, this distance can be obtained by adding the security margin on each side and the air plane's span.

- D: This distance can be calculated picking up the distance form C until the last airfoil and adding the contribution of the security margin.

- E: This distance required is geometrically more complex and can be obtained by creating a parallel line distanced the security margin from the line created from the tip of the last airfoil until the edge of the engine.

5.3.2 Dimensions for reference aircraft

Before stating all the distances, a reference point must be set. The centre of coordinates is placed in the nose of the plane, the x-axis is considered positive following the aircraft's direction, the y-axis is considered positive in the direction of the left half-wing and the z-axis is oriented to the ground.

5.3.2.1 B777

The dimensions of the air plane B777 are the following:

Span	64,8m
Length	73,86m
Length last airfoil	0,6m
Engine position x	25,76m
Wing tip coordinate	49,11m

Table 5.3.1: Boeing 777 distances and dimensions.

The security margin used on the B777 according to ICAO's table is 7,5m.

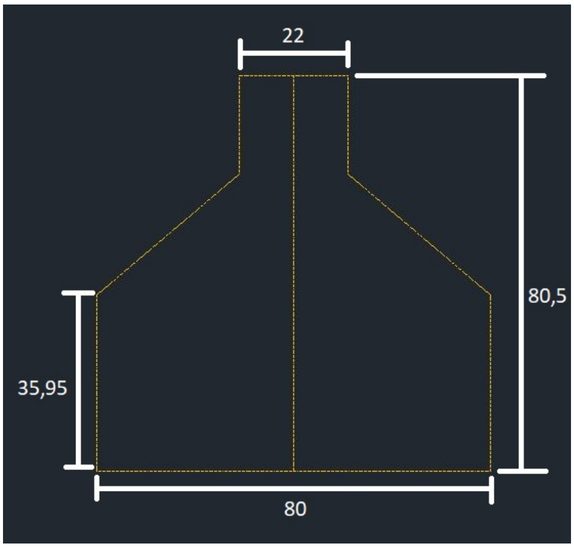

Figure 5.3.3: B777 aircraft stand dimensions.

5.3.2.2 B737

Doing the same for the B737, the table obtained is the following:

Span	35,79m
Length	39,47m
Length last airfoil	2,13m
Engine position x	13,36m
Wing tip coordinate	23,88m

Table 5.3.2: Boeing 737 distances and dimensions.

The security margin used on the B737 according to ICAO's table is 4,5m. The next image shows the B737 aircraft's stand:

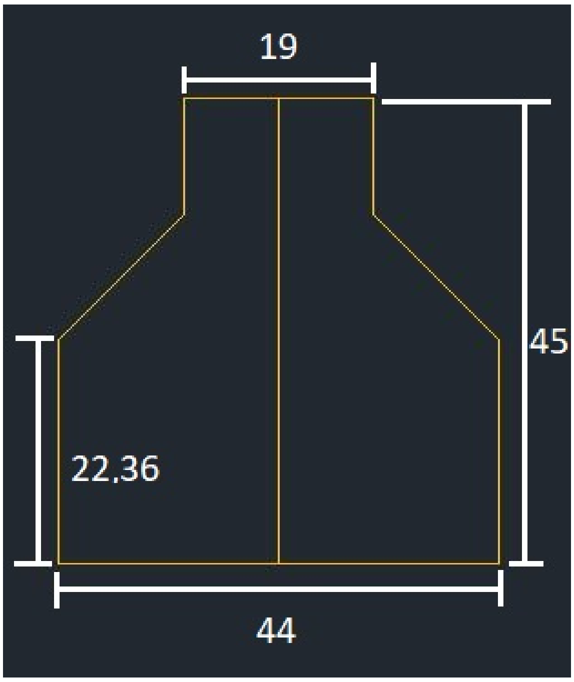

Figure 5.3.4: B737 aircraft stand dimensions.

5.4 Service ways in apron

The service ways are used for different vehicles in order to complete a mission in a plane or in another place of the apron. The legislation followed by this type of road depends on the General Traffic Direction. In order to ease the procedures, the legislation that will be followed is the one stated on the Real Decreto 2086/2011 published by the Spanish General Traffic Direction.

The most restrictive vehicle that will use the service ways is the truck. Following the legislation mentioned above, the minimum radius is 12,8m. The total width chosen in order to facilitate and increase the security on those vehicles is 21m, 10,5m for each direction.

As it can be seen on the drawings, the service way is designed in order to supply both the apron and the remote taxi ways. Due to the fact that the service way goes across with the auxiliary taxiways, the legislation states that two signs which guarantee aircraft preference over the other vehicles are a must in the intersection points. In addition, a sign that reminds the drivers to be careful with the jet-blast gases of the air planes is required. The signs used are shown below:

Figure 5.4.1: Sign that informs of an intersection with an aircraft.

Figure 5.4.2: Sign that informs of Jet Blast.

Furthermore, the way has to be supplied with the general traffic signs following the Spanish GTD.

The next image shows the final design of the service way in purple colour. It surrounds the terminal in order to supply the planes parked on the apron and also extends until the remote parking area in order to supply the other aircraft.

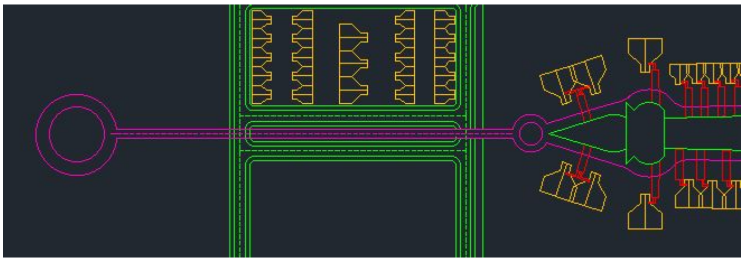

Figure 5.4.3: Final desgin of the service way.

5.5 Terminal connections

In this section, the connection with fingers between the planes and the terminal will be explained.

Due to the fact that our terminal has two floors, the lower one for the arrivals and the upper for the departures, an auxiliary structure before the finger is needed in order to ease the boarding procedure. This structure will be used in order to manage and distribute the flux of passenger entering and exiting the air plane. The departure passengers will start in the upper level and will be able to board directly using the finger. However, the procedure is different during the exit of the plane. Once the passengers have left the air plane and the finger, they will be required to get down to the lower floor using an escalator placed on the auxiliary structure. Thus, they will enter the terminal directly on the arrivals floor.

There is a total number of 28 fingers and they are placed as its shown:

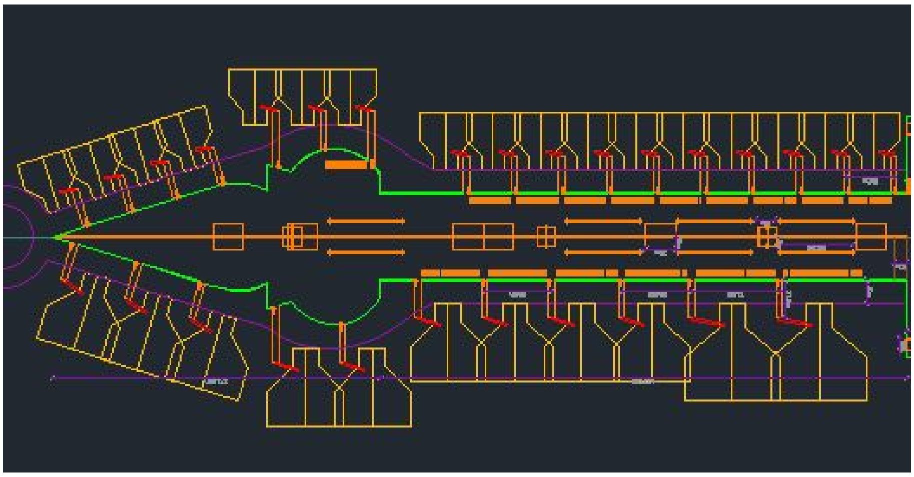

Figure 5.5.1: General view of all the fingers connected to the terminal.

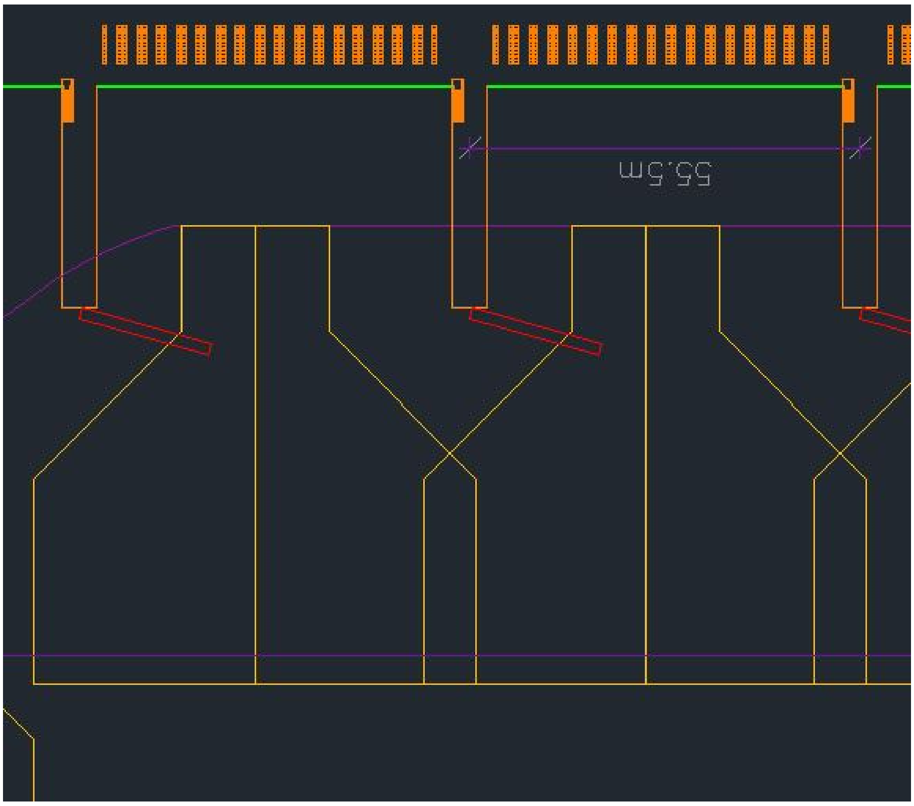

Figure 5.5.2: Close up view of some Boeing 737 stands with their respective finger connection.

6 Markings

6.1 Runway markings

6.1.1 Runway centerline markings

6.1.2 Runway side strip markings

6.1.3 Runway threshold markings

6.1.4 Runway ldesignation marking

6.1.5 Runway aiming point markings

6.1.6 Runway touchdown zone markings

6.2 Taxiway markings

6.2.1 Taxiway centerline markings

6.2.2 Taxiway strip markings

6.2.3 Taxiway holding position markings

6.2.4 Intermediate holding position markings

6.2.5 Runway entry holding position markings

6.2.6 Mandatory instruction marking

6.3 Apron markings

6.3.1 Apron lead in line markings

7 | Lights

7.1 Runway lights

7.1.1 Approach lights

Due to the airport characteristics, it is defined as a precision approach runway II and III. According to that ICAO's classification, the starting point in order to design the approach lights is the rule 5.3.4.22.

The approach lighting system shall consist of a row of lights on the extended centre line of the runway, extending, wherever possible, over a distance of 900 m from the runway threshold. In addition, the system shall have two side rows of lights, extending 270 m from the threshold, and two crossbars, one at 150 m and one at 300 m from the threshold. Furthermore, the lights forming the centre line shall be placed at longitudinal intervals of 30 m with the innermost lights located 30 m from the threshold. Moving into the point 5.3.4.24, the lights forming the side rows shall be placed on each side of the centre line, at a longitudinal spacing equal to that of the centre line lights and with the first light located 30 m from the threshold. Where the serviceability level of the approach lights specified as maintenance objectives in 10.5.7 can be demonstrated, lights forming the side rows may be placed on each side of the centre line, at a longitudinal spacing of 60 m with the first light located 60 m from the threshold. The lateral spacing (or gauge) between the innermost lights of the side rows shall be not less than 18 m nor more than 22.5 m, and preferably 18 m, but in any event shall be equal to that of the touchdown zone lights.

Both points 5.3.4.25 and 5.3.4.27 are related to the crossbars. The crossbar provided at 150 m from the threshold shall fill in the gaps between the centre line and side row lights while the one provided at 300m shall extend on both sides of the centre line lights to a distance of 15 m from the centre line.

The next image taken from annex 14 sums up all the points and requirements stated above:

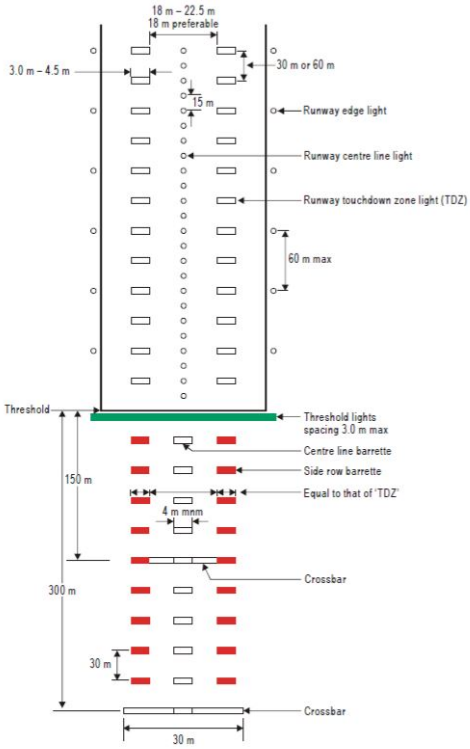

Figure 7.1.1: Schematic figure representing the approaching lights.

Characteristics

According to ICAO, the centre line of a precision approach category II and III lighting system for the first 300 m from the threshold shall consist of barrettes showing variable white, except that, where the threshold is displaced 300 m or more, the centre line may consist of single light sources showing variable white.

Since the threshold of both runways is not displaced more than 300m, the centre line will consist of barrettes showing variable white. Those barrettes has to have a minimum length of 4m according to the article number 5.3.4.33.

The side row shall consist of barrettes showing red. The length of a side row barrette and the spacing of its lights shall be equal to those of the touchdown zone light barrettes.

7.1.2 Approach slope indication systems

There are 4 types of approach slope indication systems: T-VASIS, AT-VASIS, PAPI AND APAPI. Depending on the system chosen, the design may change. In order to ease the maintenance costs and due to its easy design and installation, the system chosen is the PAPI. The recommendations and the rules that affect the PAPI and APAPI design range from the statement number 5.3.5.24 until the 5.3.5.41 inclusive.

Description

The PAPI system shall consist of a wing bar of four sharp transition multi-lamp units equally spaced and the system shall be located on the left side of the runway unless it is physically impracticable to do so.

The wing bar of a PAPI shall be constructed and arranged in such a manner that a pilot making an approach will:

a) When on or close to the approach slope, see the two units nearest the runway as red and the two units farthest from the runway as white.

b) When above the approach slope, see the one unit nearest the runway as red and the three units farthest from the runway as white; and when further above the approach slope, see all the units as white.

c) When below the approach slope, see the three units nearest the runway as red and the unit farthest from the runway as white; and when further below the approach slope, see all the units as red.

Calculations

The location of the PAPI system should be the one that brings the highest compatibility with all the other visual and non-visual factors, considering facts such has the vertical distance of the pilot and the antenna of the planes that regularly use the runway. The distance is going to be equal to the medium length between the threshold and the beginning of the landing, adding a corrector factor due to the difference between the vertical length of the pilot eyes and the antenna. This factor can be obtained by multiplying the medium vertical distance between the pilot eyes and the antenna with the cotangent of the approximation angle.

Considering the landing distance of 400m and making use of the Annex 14, the factor of correction can be obtained considering a landing angle of 3°. The value obtained is 53,31m. Thus, the final PAPI location is 453,31m.

In order to state the perpendicular distance between the PAPI and the runway, the following picture taken from ICAO's manual determines that value.

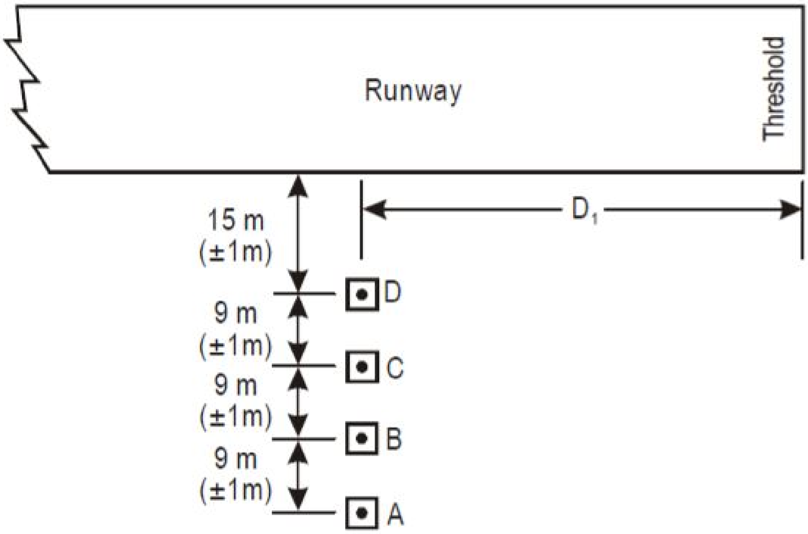

Figure 7.1.2: Vertical distance between the PAPI and the runway.

In order to ensure the visibility of the PAPI system, an area empty of obstacles must be defined. The parameters that define this protective surface are gathered in the following table extracted from the Annex 14, chapter 5:

	Runway type/code number							
	Non-instrument Code number				Instrument Code number			
Surface dimensions	1	2	3	4	1	2	3	4
Length of inner edge	60 m	80 m[a]	150 m	150 m	150 m	150 m	300 m	300 m
Distance from the visual approach slope indicator system[e]	D_1+30 m	D_1+60 m	D_1+60 m	D_1+60 m	D_1+60 m	D_1+60 m	D_1+60 m	D_1+60 m
Divergence (each side)	10%	10%	10%	10%	15%	15%	15%	15%
Total length	7 500 m	7 500 m[b]	15 000 m	15 000 m	7 500 m	7 500 m[b]	15 000 m	15 000 m
Slope								
a) T-VASIS and AT-VASIS	–[c]	1.9°	1.9°	1.9°	–	1.9°	1.9°	1.9°
b) PAPI[d]	–	A–0.57°	A–0.57°	A–0.57°	A–0.57°	A–0.57°	A–0.57°	A–0.57°
c) APAPI[d]	A–0.9°	A–0.9°	–	–	A–0.9°	A–0.9°	–	–

Figure 7.1.3: Dimensions and slopes of the obstacle protection surface.

The following figure extracted from the ICAO's manual can ease the understanding of the PAPI and its protection surface function:

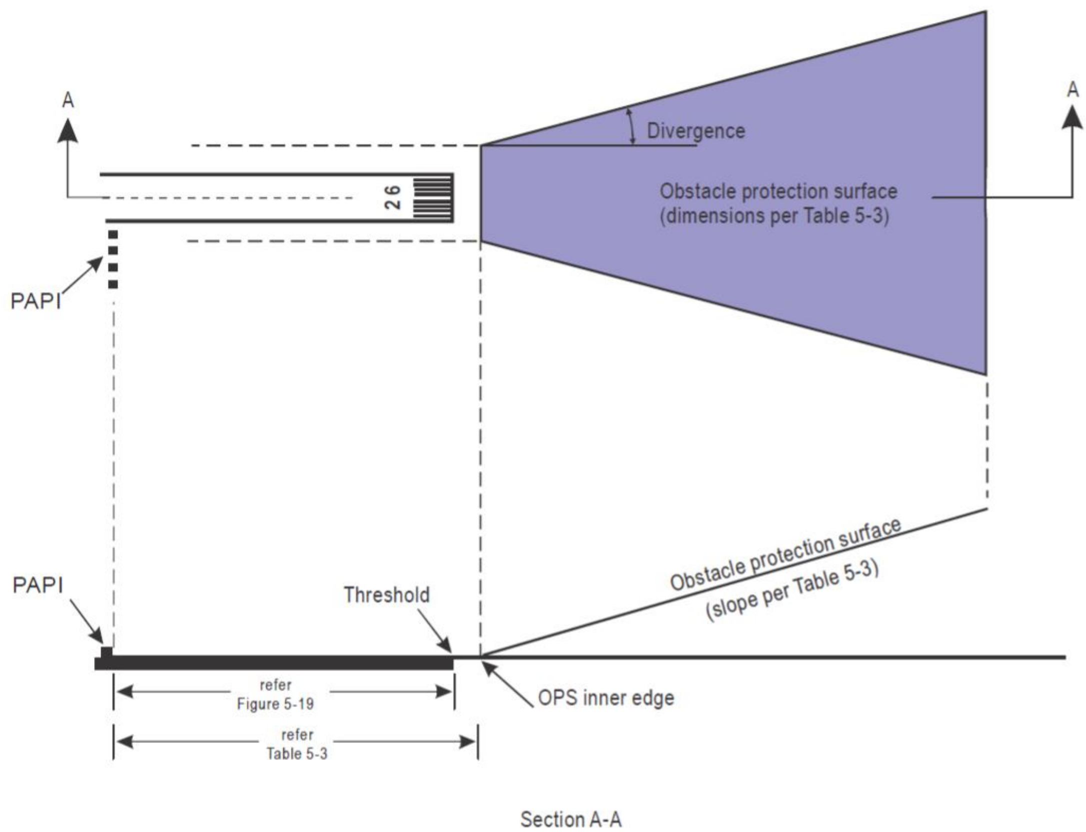

Figure 7.1.4: Protection surface scheme and PAPI positioning.

7.1.3 Runway threshold identification lights

The rules that regulate the runway threshold identification lights can be found on chapter 5.3.8 of the Annex 14. As a conclusion, the following statements define when should the threshold identification lights be included in the airport's installation:

- In a visual approximation runway, when there are no more other reliable visibility aids.

- The threshold is permanently or temporary displaced from the beginning of the runway.

Due to the fact that non of those requirements are meet, those lights have been discarded.

7.1.4 Runway edge lights

Unlike the last set of lights, the runway edge lights are a must since the airport is expected to work during night time too.

Runway edge lights shall be placed along the full length of the runway and shall be in two parallel rows equidistant from the centre line. Their distance from the edge should not exceed the 3m. Furthermore, The lights shall be uniformly spaced in rows at intervals of not more than 60 m for an instrument runway.

Runway edge lights shall be fixed lights showing variable white except 600m before the end of the runway, in this case, may show yellow.

7.1.5 Runway threshold and wing bar lights

Runway threshold will be provided since the runway is equipped with runway edge lights.

Location

The threshold lights shall be placed in a row at right angles to the runway axis as near to the extremity of the runway as possible and, in any case, not more than 3 m outside the extreme. Furthermore, due to our approximation category, the lights will be uniformly spaced between the rows of runway edge lights at intervals of not more than 3 m.

The use of wing bars is discarded since any of the runways is considered a visual approaching runway.

Characteristics

Runway threshold and wing bar lights shall be fixed unidirectional lights showing green in the direction of approach to the runway.

7.1.6 Runway end lights

Following ICAO's legislations, runway end lights shall be provided for a runway equipped with runway edge lights. Their location is on a line as close as possible to the end of the runway, in any case, not more than 3 m outside the end.

Characteristics

Runway end lights shall be fixed unidirectional lights showing red in the direction of the runway. The intensity and beam spread of the lights shall be adequate for the conditions of visibility and ambient light in which use of the runway is intended.

The final configuration adding the contribution of the end lights and the threshold lights is the following:

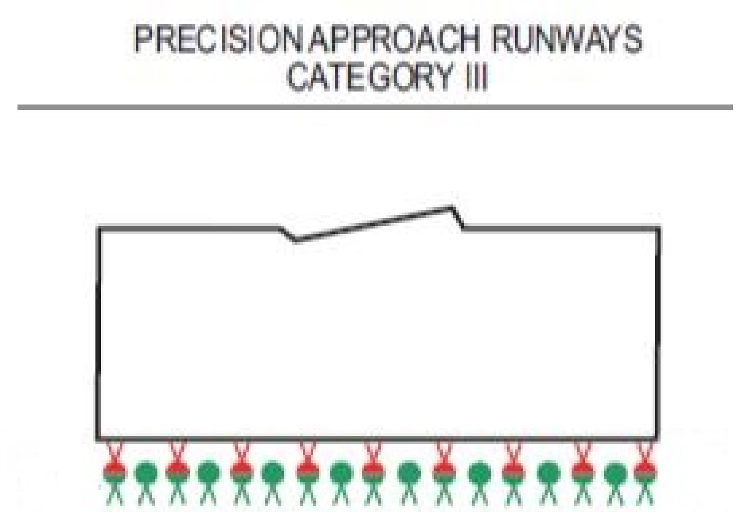

Figure 7.1.5: Scheme showing the lights placed on the edge of the runway.

7.1.7 Runway centre line lights

According to 5.3.12.11 the airports with precision approach runway of category II or III must provide centre line lights.

Location

Runway centre line lights shall be located along the centre line of the runway, except that the lights may be uniformly offset to the same side of the runway centre line by not more than 60cm. The lights shall be located from the threshold to the end at longitudinal spacing of approximately 15m.

Characteristics

Runway centre line lights shall be fixed lights showing variable white from the threshold to the point 900 m from the runway end; alternate red and variable white from 900 m to 300 m from the runway end; and red from 300 m to the runway end, except that for runways less than 1 800 m in length, the alternate red and variable white lights shall extend from the midpoint of the runway usable for landing to 300 m from the runway end.

7.1.8 Touchdown zone lights

Location

Touchdown zone lights shall extend from the threshold for a longitudinal distance of 900m and the longitudinal spacing between pairs of barrettes shall be either 30m or 60m.

Characteristics

A barrette shall be composed of at least three white unidirectional variable lights with a spacing between the lights of not more than 1,5m. Its length will be higher than 3 and lower than 4,5m in order to successfully follow the recommendation 5.3.13.4.

7.1.9 Rapid exit taxiway indicator lights

A set of rapid exit taxiway indicator lights shall be located on the runway on the same side of the runway centre line as the associated rapid exit taxiway. In each set, the lights shall be located 2 m apart and the light nearest to the runway centre line shall be displaced 2 m from the runway centre line. Furthermore, rapid exit taxiway indicator lights shall be fixed unidirectional yellow lights, aligned so as to be visible to the pilot of a landing aeroplane in the direction of approach to the runway.

The following scheme simplifies the explanation shown above and can also be used to give an example of the application of the rapid exit taxiway indicator lights:

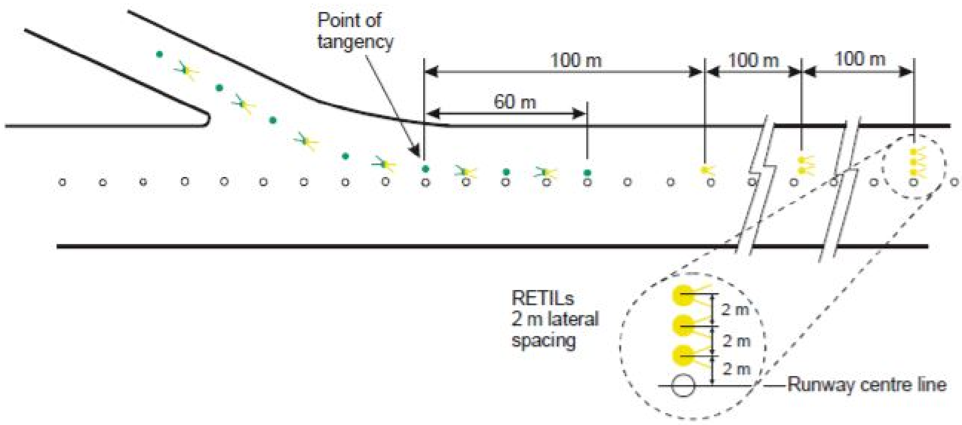

Figure 7.1.6: Example of rapid exit runway lights.

7.2 Taxiway lights

7.2.1 Taxiway lights

7.2.2 Taxiway lights for an exit taxiway

7.2.3 Taxiway light for a rapid exit taxiway

7.2.4 Taxiway edge lights

7.2.5 Stop bar lights

7.2.6 Intermediate holding point lights

7.3 Apron lights

7.3.1 Line and edge apron lights

7.3.2 Projector based apron lighting

7.3.3 Visual guidance system for parking

8 Signs

8.1 Mandatory instruction signs

8.2 Information signs

9 High-voltage electrical system

10 Medium voltage electrical system

10.1 Beacon circuits

10.1.1 Runway centerline lighting system

10.1.2 Taxiway centerline lighting system

10.1.3 Runway and taxiway centerlines lighting system

10.1.4 Approach lighting system

10.1.5 Touchdown zone lighting system

10.1.6 Runway header lighting system

10.1.7 RETIL electrical circuit

10.1.8 PAPI electrical circuit

10.1.9 Stop bar electrical circuit

10.1.10 Signs electrical circuit

10.2 Regulation chambers

10.3 Wire channeling

11 Aeronautical limitation surfaces

11.1 Physical limitation surfaces

11.2 ILS limitation surfaces

11.3 Localizer limitation surfaces

11.4 Gliding trajectory protection limitation surfaces

12 | Bibliography